David L. Huffman

Engineering Note

Date: January 2, 2003
Rev Date:

Project: Fan Speed Monitoring
Doc. No: h030102

Subject: Calorimeter Preamp Fan Speed Monitoring

1. General Description

1.1. Brief history

1.1.1. The Preamp boxes were reworked for Run II with a new air-cooling system. Three fans were installed two small Muffin [1]fans and one larger Maltese [2]unit. A failure of a larger fan made it obvious that the system will not provide adequate cooling with just the two smaller fans. The question asked is 'can the fan speed be monitored and provide notice of an impending failure'?

1.1.2. To answer this question a system that can monitor small changes in fan speed would have to be implemented. The simplest way to implement monitoring and use existing hardwarewould be to use the spare analog inputs on the temperature monitoring Rack Monitor chassis in each section of the detector and provide a speed to voltage circuit from each fan. Furthermore in order to view small changes in fan speed an expanded window of the nominal speed would have to be provided.

1.1.3. The fans do not have a tachometer option available so a pickup must be engineered to provide the rotational velocity. The least invasive method is an optical pickup with a light-dark pattern attached to the fan blade. A commercial infrared source and detector is utilized.

2. Circuit Details

2.1. Since we are looking for small changes in RPM stability is very important. Accuracy is not necessary however resolution is needed. Long-term stability is very important since that will be the parameter that determines when there is a fan problem. The circuit will be set for 1mv/1RPM scale factor. This should allow us to see a 5RPM change in fan speed.

2.2. The circuit design that provides the desired monitoring operates as follows. The optical pickup senses the reflection of a series of light-dark patches attached to the fan blade. The sensor and associated electronics shadow the fan motor to stay out of the airflow as much as possible. A high frequency at the pickup is desired therefore as fine a grid as practical will be used. The higher frequency will have smaller component values for filtering ripple. The filtered ripple should be less than one ADC count (5mv) into the Rack Monitor.

2.3. The analog signal from the sensor is conditioned and converted to digital with an LM311 comparator. The comparator has feedback to provide hysteresis preventing oscillations during slowly changing levels. The digital signal is converted to a fixed width using a one-shot. The timing capacitor here is critical in terms of stability and polypropylene will be used. Next the output signal is filtered with a simple RC. The nominal average signal at this point should be around 2.3V.

2.4. The final stage is an active integrator that incorporates offset subtraction and amplification. The gain and offset subtraction provides an expanded range around the nominal fan speed. As the fan speed decreases the output will decrease linearly with RPM. Since there is amplification the minumum RPM at 0V is 1170RPM. The equation for RPM is (Vreadback*940+1170)

2.5. Three fan sensors operate off a single 6-conductor cable and twelve fans are collected into one interface box that connects to one analog input connector (P10) on the temperature rack monitor chassis. The interface box provides power for the electronics with an AC adapter type power supply.

3. Software

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[1] Comair Rotron MX2B3

[2] Comair Rotron MA2B3

3.1. Data base entries are required before the fan speed can be read back in the Archiver. The channel, scale factor, engineering units and offset et cetra are provided in the table below.

Preamp Fan PV Names

	Left side	Right Side
CALN_CMCP_PA00	/FAN1L,FAN2L,FAN3L	/FAN1R,FAN2R,FAN3R
CALN_CMCP_PA01	/FAN1L,FAN2L,FAN3L	/FAN1R,FAN2R,FAN3R
CALN_CMCP_PA10	/FAN1L,FAN2L,FAN3L	/FAN1R,FAN2R,FAN3R
CALN_CMCP_PA11	/FAN1L,FAN2L,FAN3L	/FAN1R,FAN2R,FAN3R
CALC_CMCP_PA02	/FAN1L,FAN2L,FAN3L	/FAN1R,FAN2R,FAN3R
CALC_CMCP_PA03	/FAN1L,FAN2L,FAN3L	/FAN1R,FAN2R,FAN3R
CALC_CMCP_PA08	/FAN1L,FAN2L,FAN3L	/FAN1R,FAN2R,FAN3R
CALC_CMCP_PA09	/FAN1L,FAN2L,FAN3L	/FAN1R,FAN2R,FAN3R
CALS_CMCP_PA04	/FAN1L,FAN2L,FAN3L	/FAN1R,FAN2R,FAN3R
CALS_CMCP_PA05	/FAN1L,FAN2L,FAN3L	/FAN1R,FAN2R,FAN3R
CALS_CMCP_PA06	/FAN1L,FAN2L,FAN3L	/FAN1R,FAN2R,FAN3R
CALS_CMCP_PA07	/FAN1L,FAN2L,FAN3L	/FAN1R,FAN2R,FAN3R

Table 1

There are 72 fans each with a name derived from the table above. One item from each column is used to form the name with the last two columns determining the right or left side. For example CALC_CMCP_PA02/FAN2L would be the second fan in the left side of Preamp Box 02.

4. Electrical

4.1. Schematics

4.1.1. Interface Box

1.1.1.1. Reference Figure 4 which shows the Interface Box. The power is provided to the sensor boards and the signal directed to the Rack Monitor chassis. Four twelve pin connectors are mapped to the 37pin subminiature ‘D’ connector. Each of the twelve pin headers goes to three fans.

4.1.2. Sensor Cables

1.1.1.2. Reference Figure 5. Cabling from the Interface Box to the sensors. The cable from each 12 pin header cnnector splits to three 4 pin connectors.

4.1.3. Sensor

1.1.1.3. Reference Figure 6. The sensor

4.2. PCB

4.2.1. Assembly

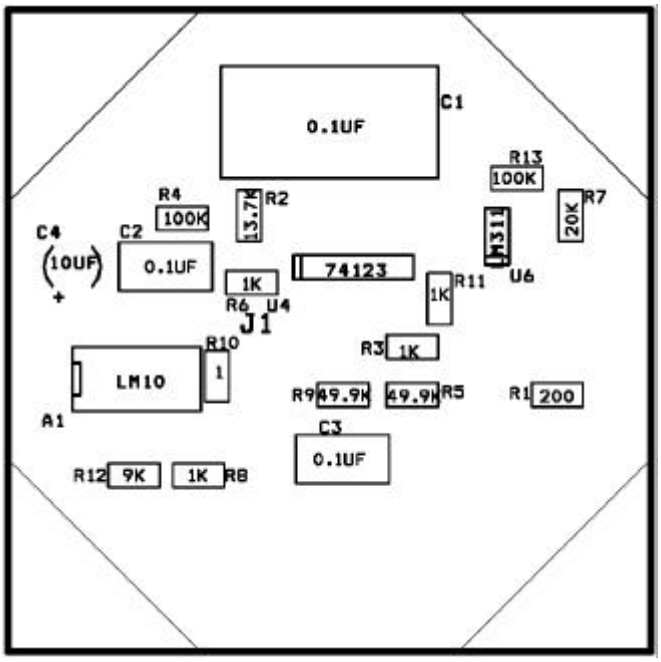


Figure 1 Assembly Drawing

4.2.2. Traces

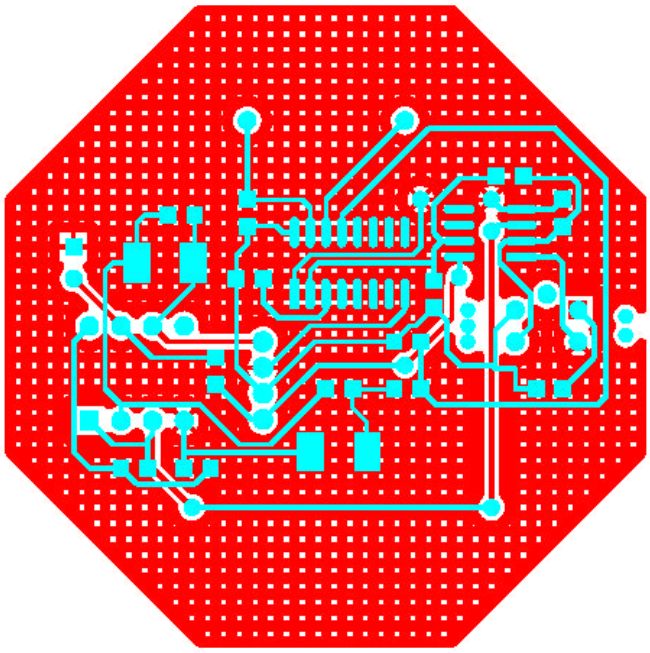


Figure 2 Traces Layer 1 & 2

5. Mechanical

5.1. Optical Pickup Label

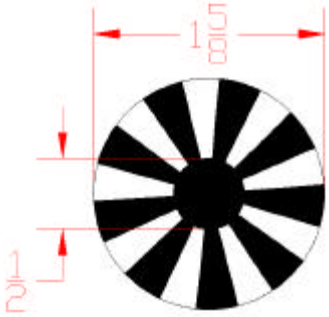


Figure 3 Optical Label

5.1.1. The sensor and electronics PCB is mount on the fan behind the motor-blade. The muffin fans attach diagonally and the larger fan attaches horizontally. The pickups are identical and have plugs for easy replacement.

5.2. Small fan mounting sketch.

Figure 4 Modify a ring tongue as shown and solder to the ends of the brass tube.

5.3. Large fan mounting sketch.

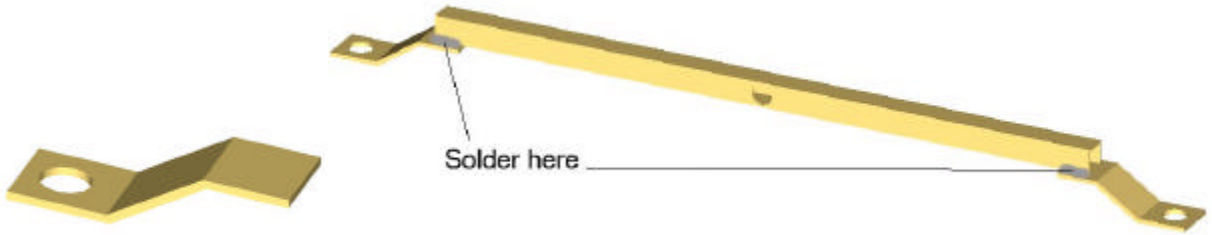
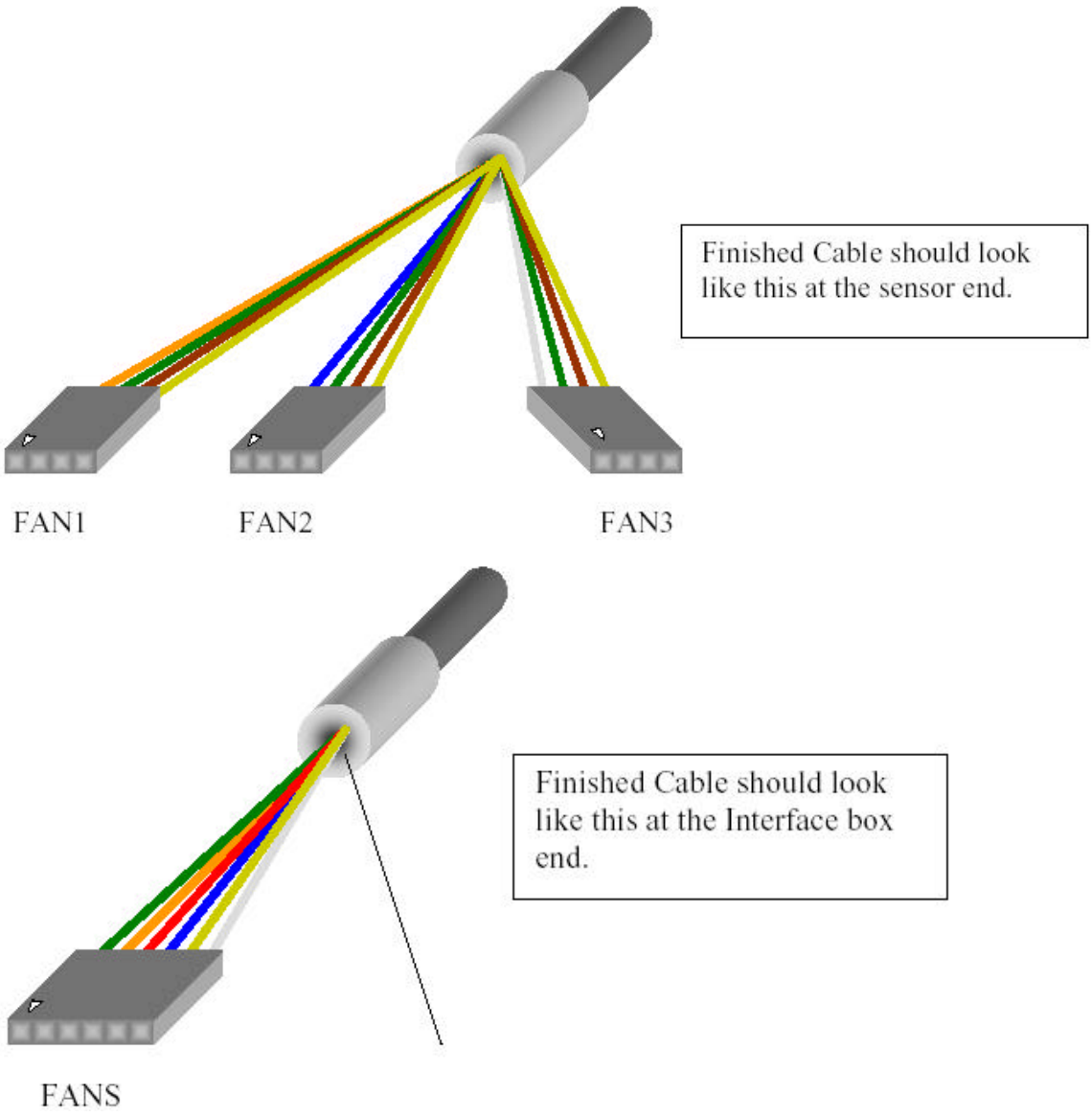


Figure 5

5.4. Sensor Cable assembly



BOM

Sensor Assembly

Item	Quantity	Reference	Part	Manuf. #
All	72			
1	1	1	A1	LM10
2	2	2	C3,C1	0.1uf
3	3	2	C5,C2	1uF
4	4	1	C4	10uF
5	5	1	J1	pads for wire
6	6	1	R1	499
7	7	1	R2	13.7K
8	8	4	R3,R6,R8,R11	1K
9	9	2	R13,R4	100K
10	10	2	R9,R5	49.9K
11	11	1	R7	20K
12	12	1	R10	1
13	13	1	R12	9K
14	14	1	U3	GP2S28
15	15	1	U4	74HC123
16	16	1	U6	LM311
16	1	P2	Molex 4-pos plug	538-50-57-9404
17	1	J2	Molex 4-pos socket	538-70107-0004
18	1		Square Brass Tubing 6"	8859K44
19	2		Pillar standoff 1/4" insulating	1465-055000
20	2		Ring Tongue 10 AWG # 6 screw	
21	1		PCB	
22			nylon screw w/nut 6-32	
23	1		Frick Label Target	FL-1.625-CIRCLE

Interface Chassis and Power Supply

Item	Quantity	Reference	Part	Manuf. #
All	6			
1	1		Power Supply	ESP126-ND
2	1		PCB	
3	1		Small Box	
4	1		37pin F Subminiature D	
5	4		12 pos header	
6	20		6-cond 26AWG cable	

Table 2

6. Large Figures

6.1.

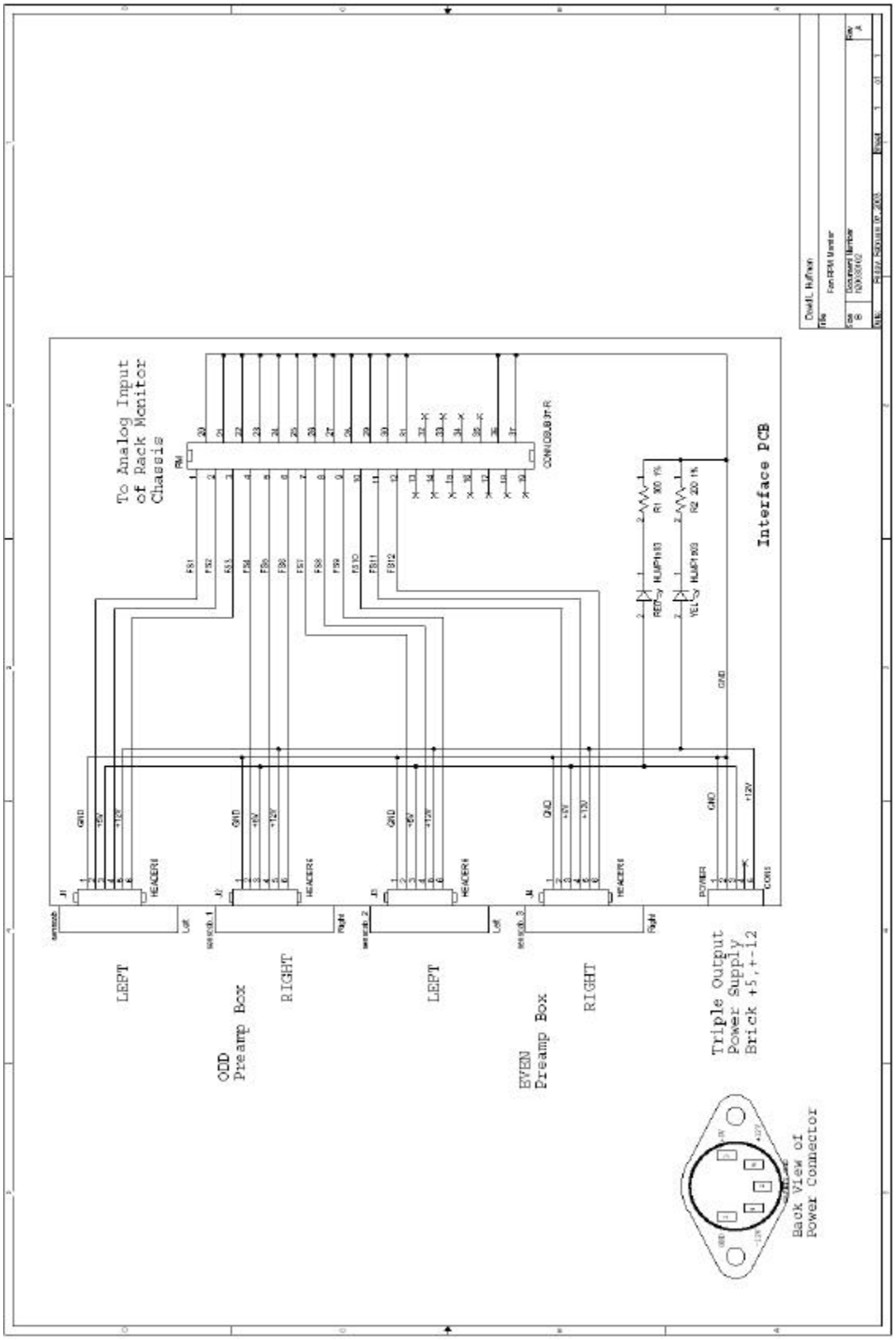


Figure 6 Top Level Schematic

6.2.

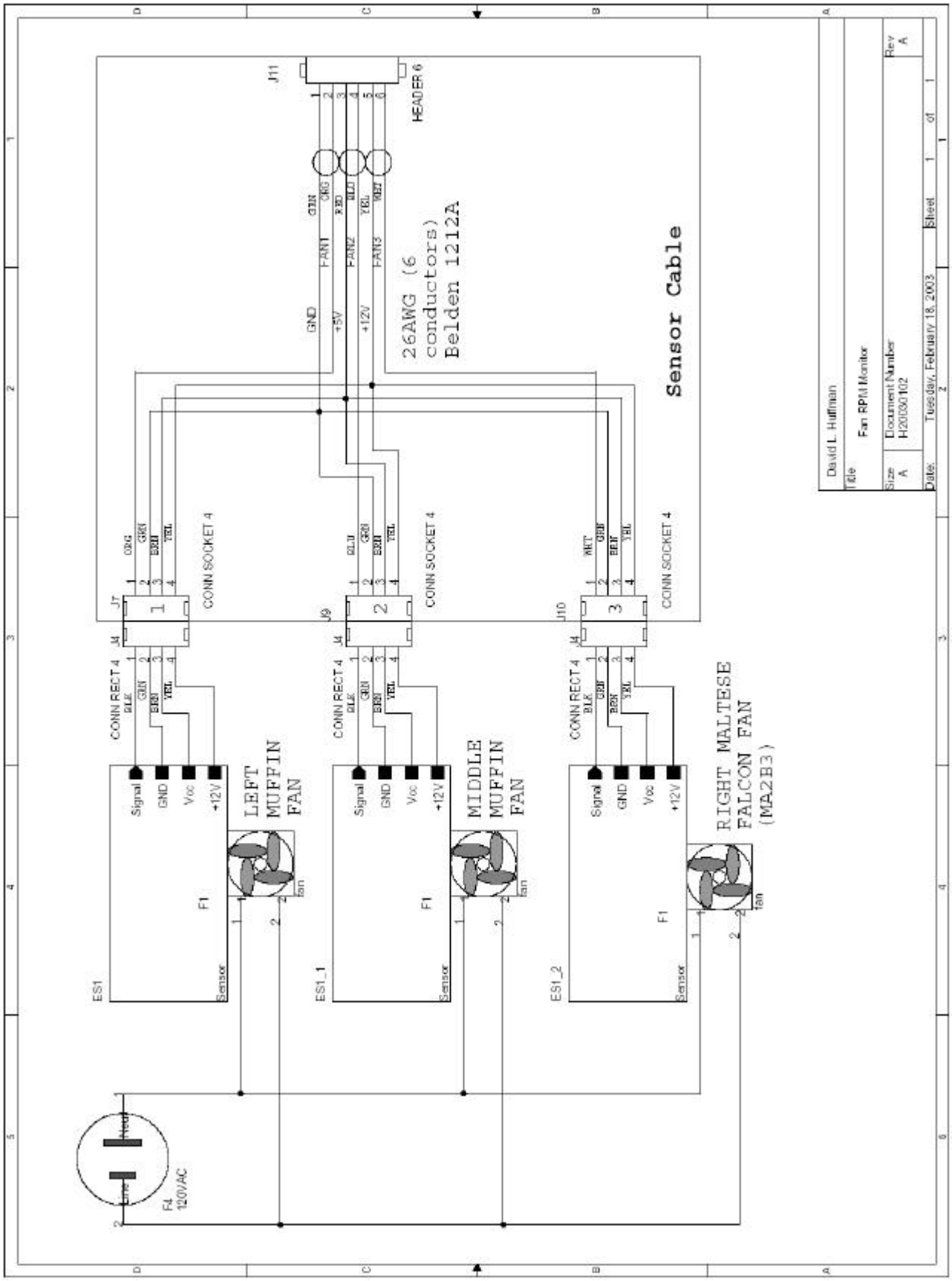


Figure 7 Sensor Cabling

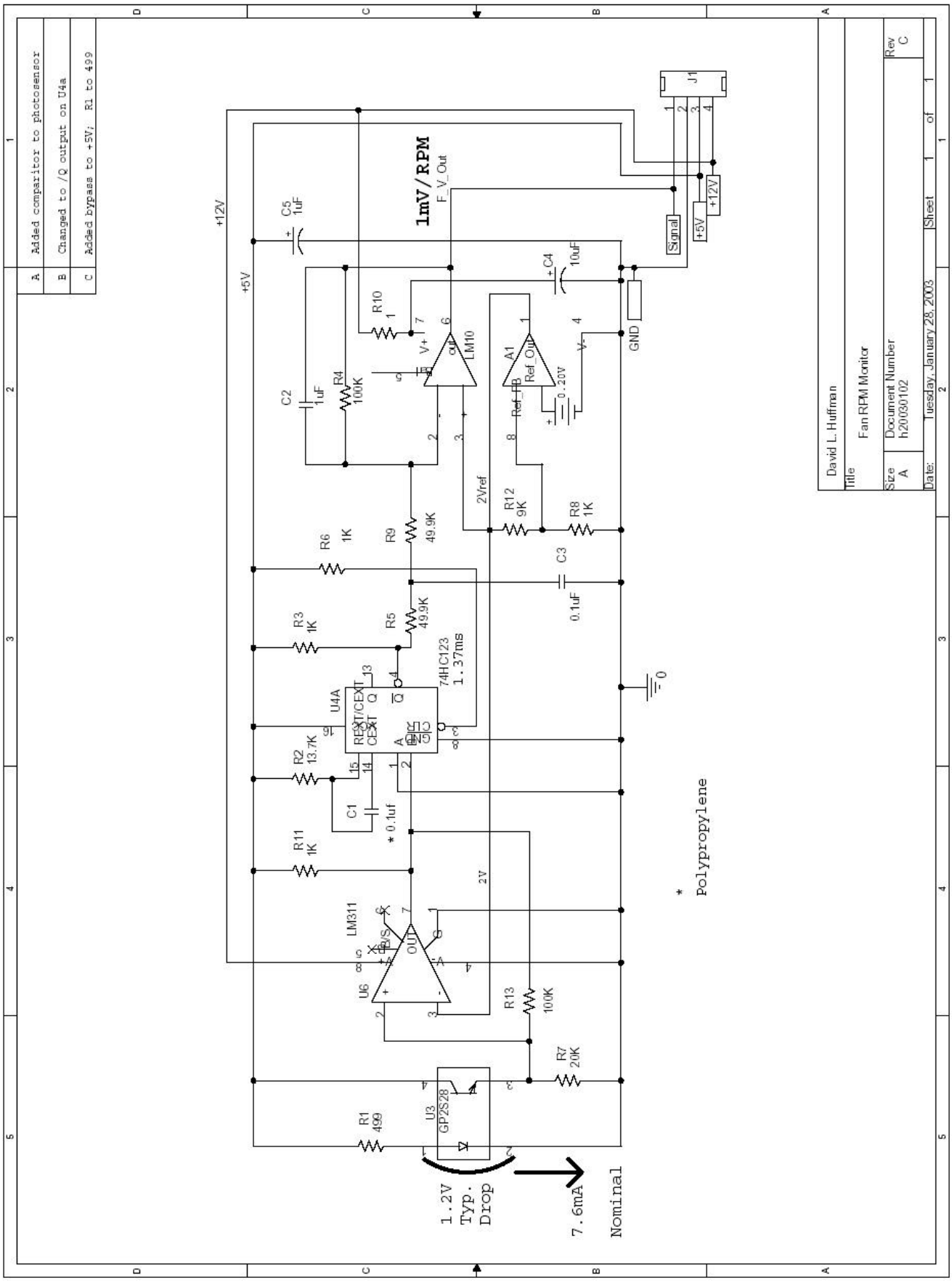


Figure 8 Sensor Electronics